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NOTES ON THE RECENT PROGRESS OF IRRIGATION IN THE UNITED STATES.

BY

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These notes are derived chiefly from the later irrigation papers of the United States Department of Agriculture and from the irrigation literature of the United States Geological Survey, appearing during the past decade. In the Yearbook of the Department of Agriculture for 1899, the "Rise and Future of Irrigation in the United States" is reviewed by Elwood Mead, Expert in Charge of Irrigation Investigations. This is one of a series of historical papers in the same volume, and is perhaps the most comprehensive single utterance upon the subject.

NATIONAL IMPORTANCE REALIZED.

It can truly be said that we are now beginning to appreciate the meaning of irrigation as a national interest. In the recent annual report of President Wheeler, of the University of California, a department of irrigation is enumerated among the needs of the institution. Almost at once it is reported that such a department has been founded, and that Professor Elwood Mead has been called to fill the chair. The University of Wyoming already gives a course in irrigation; and while specific data are not before the writer, it is safe to say that all agricultural schools within the arid region recognize the subject in some degree. Nor is it forgotten farther east—as, for example, in the horticultural department of the University of Wisconsin. Indeed, all artificial watering of plants falls within the scope of this great department of practical science.

Professor Mead, in the article above named, makes instructive reference to the beginnings of this work in America—in Utah a half-century ago (July, 1849), and at Greeley, Colo. (founded in 1870): "The highest methods both of irrigation and cultivation were sought out through numberless experiments, until Greeley and its potatoes grew famous together. The home and civic institutions of the colony became the pride of the State, and the hard-won success of the community inspired numerous similar undertakings, and furnished an impulse which resulted in the recla-

mations and settlement of northern Colorado." In the light of these inspiring beginnings, the extent of our arid territory gathers surprising meaning. Somewhat more than one-third of the entire territory of the United States, exclusive of Alaska, must depend on artificial watering for its agriculture. Except in limited degree for grazing, these lands have no value without water. With water, they are unsurpassed in fruitfulness. Experts believe that about one-tenth of the total body of arid land can be brought under the plough, if all the water is used to the best advantage. Thus not land, but water, is the great problem of the West. As irrigation is extended, the number of our population increases; towns grow up, manufactures are necessary, railways are multiplied, and the country becomes richer in all the elements of civilization and national prosperity.

It is stated that for Colorado to double the duty of water would increase the public wealth of the State by \$20,000,000; to "double the duty" simply means to make the same water contribute effectively to twice the area of production now utilized. Irrigation and tillage are an essential supplement to the mining, timber and grazing resources of such a region. Cheap and abundant food in full variety is essential to symmetrical development of all the resources of the West. From the simple point of view of taxable wealth, therefore, all our citizens, east and west, have an interest in irrigation. This is the phase of the subject which is beginning to command popular and legislative attention at the national capital and throughout the country. The greatness of our problem cannot be better stated than in Professor Mead's comparison of the Nile and the Missouri:

It (the Nile) supports over 5,000,000 people and pays the interest on a national debt half as large as our own. The Missouri and its tributaries can be made to irrigate three times the land now cultivated along the Nile.

The same writer (*Yearbook Dept. of Agriculture, 1899*) sets forth the importance of irrigation for the great semi-arid belt of the Dakotas, Nebraska, Kansas and Texas, where thousands of settlers have suffered disappointment and loss in the surely recurring years of drought. Nor is this all. Some of the most recent literature of the subject deals with irrigation, its methods and value, in the humid regions. Thus Bulletins 36 and 87 of the Department of Agriculture, Office of Experiment Stations, give the results of irrigation operations in Connecticut and New Jersey. These papers show the great value of artificial watering, in dry seasons, for fruit, hay and other crops. In his report for 1899

the Secretary of Agriculture makes the interesting statement that a hundred thousand acres of sugar land are under irrigation in Louisiana. Rice fields are irrigated in the Carolinas, and irrigation is on trial in the raising of tea in South Carolina. Thus all the problems of the storage, distribution and application of water become of general interest.

PROBLEMS OF IRRIGATION.

From the introduction of irrigation into universities and technical schools, and from the large attention given by government departments, it should appear to all that the highest skill is demanded, and that the fruits of experience must be gathered and transmitted with the least waste to the practical irrigator. Little more than the mention of the problems involved falls within the scope of these notes.

We have first the selection of the land, both as to location and as to quality of soil. If but about one-tenth of the arid region can be brought to tillage, this tenth must be picked with care. If a mistake in location is made, the expense of bringing the water may defeat the purpose of profit. If the best soils within reach of the supply are overlooked, loss will still result. Hence the importance of the soil survey operations now conducted by the Department of Agriculture. Probable accessibility to markets and relation to grazing lands must also be taken into account.

The construction of canals involves questions of engineering, often of no mean kind. How large must the channel be, where it shall run, what will be the losses from leakage—these are among the obvious questions. The duty of water raises another bundle of queries, many of which await full experimentation and records of many years for their answer. The amount of effective work to be done by a given supply of water hinges on soil, climate, crop, and many other conditions.*

Further questions concern the modes of distribution over the land, and of application to various crops, such as flooding, furrow irrigation, and sub-irrigation. The choice of crops raises a query of very great practical, as well as general, interest, viz., the introduction to our own dry regions of plants which, by long periods of modification, have in other lands become adapted to arid conditions. Nowhere is the invading hand of man exhibited more effectively in the distribution of organisms.

* For compact statement on "duty of water," see Bull. U. S. Dept. Agr., No. 73, pp. 41-43, and Bull. No. 81, pp. 27-29.

The Secretary of Agriculture, in his report for 1899, says:

The Department of Agriculture is searching the dry areas of the world for plants that may be successful in furnishing the materials of food to a greater extent than is now practicable on our semi-arid regions. The introduction of sorghum, kafir corn, dry-land alfalfa, the Russian brome grasses, etc., is enabling the farmers of the states west of the Missouri to extend cultivation over lands that did not succeed in corn, or oats, or clover.

COMPLICATIONS WHEN THE LIMIT IS APPROACHED.

When all the available land is wanted for actual settlement, then irrigation assumes the highest importance, and offers the most difficult problems. With the keen attention now given, we may hope that the limits will be approached in the light of experience, and without undue friction and loss. When water from large streams is demanded, the lands will be relatively distant from the tapping point, the canals will be long and large, and the requirements of capital and engineering skill proportionately great. Here we quote Mr. J. C. Ulrich, in Bull. 73, Dept. of Agriculture, upon the magnitude of such works:

Many of these (corporation) canals are more than 50 miles long, and number their water users by hundreds. The Ridenbaugh Canal, in the Boise Valley, Idaho, furnishes water to more than 500 farmers. The High Line Canal, in Colorado, has 433 consumers under it.

Upon many streams of variable volume the water nearly or quite runs away before the season of growing crops. This is true, as cited by Professor Buffum, of some of the best-paying crops, which require water late in the season. Here he names sugar beets, alfalfa, potatoes, and orchard fruits. The same writer continues:

A second-foot of water for the month of August is worth ten to twenty times as much as the same volume for May.

All this brings in the large problem of dams and storage. With storage, and transportation through long canals, in a very dry atmosphere, loss by evaporation becomes highly important. The higher the altitude the greater also the loss. Says Professor Buffum (Bull. 81, p. 22):

In single months which are dry and windy, during the growing season, evaporation of from 7 to 10 inches is not uncommon. For the year evaporation from water surface amounts to four or five times the amount of rainfall. . . . The loss from streams, ditches, and reservoirs in the arid region from this cause is enormous.

In some areas the discharge of streams is very variable from year to year. This must be taken into account. And beyond all other complicating conditions, as the limit is approached, are the "vested rights" of individuals or companies who have taken up lands and used the water according to their own advantage and

without reference to the fullest and most economical development of the region as a whole. This brings us to one of the largest features of our subject, and one which, more pressingly than any other, demands intelligent and firm State and national regulation.

LEGAL PROBLEMS AND PUBLIC SUPERVISION.

Here we instructively quote from Farmer's Bull. No. 97, Dept. of Agriculture:

Because of uncertainty of what these rights should be, the irrigation laws of many states have been made so ambiguous and contradictory that the finite intellect is not able to interpret their meaning. As a result there are laws and court decisions to sustain about every view of stream ownership of which the mind of man can conceive. . . . In ten years the water-right litigation of one state is estimated to have cost over a million dollars.

It is interesting to note here the statement of a competent authority, that the statutes of the State of Wyoming have been so wisely drawn as to obviate in great measure such obstruction.

The recent literature shows the evolution of the private ditch, the community ditch, the corporation ditch, the District system of California and some other States, and all leading on naturally to the supervision of the State and national governments. Space forbids many references of great interest, but we must not fail to note the extent of inter-State litigation, and the necessity of some general plan of operation, as in case of the Missouri, whose waters are needed in so many different States. Otherwise there will be no end of litigation as now, or recently, between Colorado and Wyoming on the one hand, and Kansas on the other. Professor Mead puts it, as it seems, none too strongly when he says:

The entire discussion leads up to one inevitable conclusion: This is, that irrigation, over and above all other industries, is a matter demanding public supervision and control. . . . The nation alone can deal with the conflicting rights in interstate and international streams and with the construction of great reservoirs at their headwaters.

Much might be said of the advantages of irrigation, as they now begin to appear. Not only will the national wealth be enhanced and general prosperity be developed in the West, but farming will be more thorough and exact, its products more diversified, the individual holdings of land smaller, and there will come an admirable training in self-government, and the management of private and public affairs.

IRRIGATION STUDY AND LITERATURE.

Only hints can here be given of the channels through which this work is carried on. The Secretary of Agriculture, in his report for

1899, informs us that the first appropriation for investigation by that department became available July 1, 1898. Soon after, a conference of experts was held in Denver, and the work was organized under the direction of Professor Elwood Mead, for study and publication in co-operation with the experiment stations. A series of publications has appeared, from which the foregoing notes have been largely derived.

We now turn to the irrigation work of the United States Geological Survey. As the Department of Agriculture deals chiefly with the equitable distribution and profitable use of water, so the Survey is charged with the study of the water supply, and is gradually furnishing the irrigator with the data which he imperatively needs for sound progress.

The first report of the Irrigation Survey, as it has been called, appeared as one volume of the tenth annual report of the United States Geological Survey in 1890. Successive reports since that time have recorded the progress of the work. Seven quarto volumes in as many years have been devoted wholly to irrigation and general hydrography, besides important papers in other volumes of the Survey reports. In Part 2 of the Eleventh Annual Report (1891) the reader will find a good account of the needs of the arid regions in the form of statements by Major Powell before a Congressional Committee. In the same volume, 44 double-column pages are filled with a bibliography of irrigation, confessedly incomplete even at that time. The next report shows that 147 reservoir sites had been surveyed during the previous year, and contains also an extended report on irrigation under the direction of the English Government in India. This report was a record of investigation by Mr. H. M. Wilson, the author of a valuable article on irrigation, published in this *BULLETIN* in 1898.

Part 3 of the Thirteenth Annual Report contains accounts of the Platte, Yellowstone, and Upper Missouri basins, and a full review of irrigation engineering in the United States. The Seventeenth Report (1895-'96) has a discussion of the water resources of Illinois, also a paper by N. H. Darton, on artesian supply in the Dakotas—a phase of the subject which is destined to become more and more important, especially for regions at some distance from the mountains and their more abundant waters. At the time of Mr. Darton's writing, about one hundred farms were thus served in the region described.

In the Eighteenth Report, for 1896-'97, we again encounter a portly volume of 750 pages, giving progress of stream measurement

in all parts of the United States, well called a "taking account of stock," as over against the earlier "haphazard" ways. This report gives data for the Potomac, Shenandoah, and James, and, farther south, for the Roanoke, Tar, Catawba, and other waters. Thus the work of the Survey is available for problems of municipal water supply, as well as for agriculture. This volume also contains a report by Leverett on the waters of Indiana and Ohio, and an essay on reservoir construction.

In the Nineteenth Report we have another large volume devoted chiefly to stream measurements. Eastern rivers here receive larger attention than heretofore, and we find very full data upon the rivers of Maine—with the Merrimac, Connecticut, Hudson, Delaware, and Susquehanna. The Rock Waters of Ohio are discussed by the late Dr. Edward Orton, and Mr. N. H. Darton reviews the water supply of Western Nebraska. In the Twentieth Report the volume on Hydrography includes a report by Mr. A. P. Davis, detailed to investigate the hydrography of Nicaragua in the interests of the interoceanic canal project.

In addition to the annual reports, as authorized by act of Congress in 1896, a series of pamphlets has been issued, known as Water-supply and Irrigation Papers. About thirty of these have now appeared, and many subjects of immediate value to irrigators are treated. Several papers give accounts of irrigation in special regions—as, for example, near Greeley, Colo., and near Fresno, Cala. Five deal with windmills and pumping operations, two take up sewage irrigation, one discusses water-rights, and several are devoted to water supply.

This review would be incomplete without reference to the National Irrigation Association, of which Mr. George H. Maxwell is Executive Chairman and Mr. Guy E. Mitchell, Corresponding Secretary. It has a Washington office located at Room 6 Glover Building. Under the auspices of this association, an Irrigation Congress was held at Chicago late in November, 1900, and its proceedings at that time attracted attention throughout the country. The objects appear to be the dissemination of information and the promotion of national legislation on this subject. The advocates of such public action claim that no burden will be imposed on the East for the benefit of the West, but rather that the lands under the ditch can be sold to settlers at rates that will fully reimburse the Government for outlay in the construction of reservoirs and canals:

This reclamation, when accomplished, will add to the permanent taxable national wealth beyond the computation of any man. And it is easy to imagine what all this

will mean to the Eastern factory-owner, to the wholesalers, to every factor of production in the East; also, what it will mean in the way of increased freight and passenger earnings of every railway system in the nation when arid America is redeemed.

The foregoing is quoted from one of the addresses made in Chicago. If the view seems too optimistic to some, it must at least command attention. Perhaps no single economic problem in the United States is equal in importance to this, and certainly no theme surpasses irrigation in its typical geographical quality.